

## PATENT

Attorney Docket No. 51023-023

IN THE UNITED STATE PATENT AND TRADEMARK OFFICE

In re Application of: )

Hideaki KASHIHARA et al. )

Serial No.: 10/506,425 ) Group Art Unit:1751

Filed: September 2, 2004 ) Examiner: THOMAS. JAISON P

For: Anisotropic Conductive Film and Method of Producing the  
Same

Assistant Commissioner for Patents

Washington, DC 20231

Sir:

RULE 132 DECLARATION

I, Hideaki TOSHIOKA do hereby declare the followings:

I am a citizen of Japan, residing 5-3-2, Kasuga 4-chome,  
Ibaraki-shi, Osaka 567-0031, Japan;

I graduated from Molecular Engineering, Graduate School  
of Engineering, Kyoto University in 1999;

I have been employed by Sumitomo Electric Industries, Ltd.  
since 1999 and currently engaged in research activities  
relating to metallic inorganic material such as metal powder  
for anisotropic conductive films at Metals and Inorganic  
Materials Technology R&D Department of Electronics & Materials  
R & D Laboratories; and

I am a joint inventor of the invention disclosed and  
claimed in the subject application, knowing an Office Action  
dated December 14, 2006 was issued for the present invention  
noticing that the invention claimed in the subject application

was rejected under 35 U.S.C. §102 as anticipated by or, in the alternative, under 35 U.S.C. §103 as being unpatentable over Jin et al.

Experiments shown below were performed by myself or under my supervision in order to establish that the anisotropic conductive film including a metal powder that has a lot of fine metal particles previously formed in a chain shape is less than the same as the one described in Jin et al. mentioned above, and additionally has a good characteristic that Jin et al. does not provide.

<<Experiment>>

<Producing Samples>

(Sample 1)

Ni particles having a diameter of 2  $\mu\text{m}$  as that used in Example 2 of Jin et al. plated with Au to impart good conductivity was used as a conductive component. The Ni particles and an acrylic resin serving as a binding agent were mixed such that the filling factor of the Ni particles, found by the following equation (1), would be 20% by volume, and methyl ethyl ketone was added to the mixture, to prepare a paste-shaped composite material.

$$\text{filling factor (Vol. \%)} = \frac{(\text{volume of conductive component})}{(\text{total volume of solid contents})} \times 100 \quad (1)$$

Thereafter, the composite material was applied over a magnet serving as a base, was dried and solidified in a magnetic field with a magnetic flux density of 40000  $\mu\text{T}$  to produce an

anisotropic conductive film for mounting a semiconductor package as in Examples 1 to 5 and Comparative Example 1 to 3 of the present invention having a thickness of 30  $\mu\text{m}$ . Then, the cross-section thereof was enlarged for observation to confirm that a plurality of Ni particles were oriented in the thickness direction of the film.

(Sample 2)

Ni particles having a diameter of 40  $\mu\text{m}$  as that used in Example 2 of Jin et al. plated with Au was used as a conductive component. The Ni particles and an acrylic resin serving as a binding agent were mixed such that the filling factor of the metal particles, found by the equation (1), would be 20% by volume, and methyl ethyl ketone was added to the mixture, to prepare a paste-shaped composite material.

Thereafter, the composite material was applied over a magnet serving as a base, was dried and solidified in a magnetic field with a magnetic flux density of 40000  $\mu\text{T}$  to produce an anisotropic conductive film having a thickness of 30  $\mu\text{m}$ . Since the particle diameter of the Ni particles was larger than the film thickness, a plurality of the Ni particles could not be oriented in the thickness direction of the film.

(Sample 3)

Ni particles having a diameter of 40  $\mu\text{m}$  as that used in Example 2 of Jin et al. plated with Au was used as a conductive component. The Ni particles and an acrylic resin serving as a binding agent were mixed such that the filling factor of the metal particles, found by the equation (1), would be 20% by

volume, and methyl ethyl ketone was added to the mixture, to prepare a paste-shaped composite material.

Thereafter, the composite material was applied over a magnet serving as a base, was dried and solidified in a magnetic field with a magnetic flux density of 40000  $\mu\text{T}$  to produce an anisotropic conductive film having a thickness of 100  $\mu\text{m}$ . Then, the cross-section thereof was enlarged for observation to confirm that a plurality of Ni particles were oriented in the thickness direction of the film.

#### <Measurement of Connecting Resistance>

The anisotropic conductive film produced in each of Samples 1 to 3, and Example 4 of the present invention was affixed, on a flexible printed circuit board (FPC) having an electrode pattern in which Au electrodes having a width of 15  $\mu\text{m}$ , a length of 50  $\mu\text{m}$ , and a thickness of 2  $\mu\text{m}$  are arranged at 15  $\mu\text{m}$  spacing, to the electrode pattern.

A glass substrate having an Al film deposited on its one surface was then thermally bonded upon being pressed at a pressure of 10 g per electrode while being heated to 100°C in a state where it was superimposed on the anisotropic conductive film such that the Al film would be brought into contact therewith.

A resistance value between the two adjacent Au electrodes which are conductively connected to each other through the anisotropic conductive film and the Al film was measured, and the measured resistance value was reduced by half to be a connecting resistance in the thickness direction of the anisotropic conductive film.

The results are shown in Table 1. Evaluations in Table 1 are respectively as follows:

Excellent: The connecting resistance is not more than 0.10. The conductive properties in the thickness direction are significantly good.

Good: The connecting resistance exceeds 0.10 and is not more than 10. The conductive properties in the thickness direction are good.

Poor: The connecting resistance exceeds 10. The conductive properties in the thickness direction are bad.

#### <Measurement of Insulating Resistance>

The anisotropic conductive film produced in each of Samples 1 to 3, and Example 4 of the present invention was affixed to the electrode pattern on the same FPC as that used in the foregoing.

A glass substrate having no Al film deposited thereon at this time was then thermally bonded upon being pressed at a pressure of 10 g per electrode while being heated to 100°C in a state where it was superimposed on the anisotropic conductive film.

A resistance value between the two adjacent Au electrodes to which the glass substrate was thermally bonded through the anisotropic conductive film was measured to be an insulating resistance in the plane direction of the anisotropic conductive film.

The results are shown in Table 1. Evaluations in Table 1 are respectively as follows:

Excellent: The insulating resistance exceeds 1GΩ. The insulating properties in the plane direction are significantly

good.

Good: The insulating resistance exceeds 1 MO and is not more than 1GO. The insulating properties in the plane direction are good.

Poor: The insulating resistance is not more than 1MO. The insulating properties in the plane direction are bad.

Table 1

	Connecting resistance measured value (evaluation)	Insulating resistance measured value (evaluation)
Example 4	0.050 (Excellent)	1GO (Good)
Sample 1	1.50 (Poor)	200KO (Poor)
Sample 2	10 (Good)	30 (Poor)
Sample 3	1.80 (Poor)	50 (Poor)

Table 1 confirms that the anisotropic conductive film of Sample 1 including only Ni particles as a conductive component that corresponds to the first particles in Jin et al. and has a diameter of 2  $\mu\text{m}$  oriented in the thickness direction of the film is high in connecting resistance and poor in conductivity in the thickness direction of the film, still low in insulating resistance and poor in insulating properties in the plane direction of the film. Then, the cross-section of the anisotropic conductive film after thermal bonding is enlarged and observed to show the reasons of lowering conductivity in the thickness direction of the film as follows:

the disorientation of the Ni particles caused by the flow

of the resin at the time of the thermal bonding disperses scatteringly the Ni particles in the film so that the good conductive network is not maintained;

the number of the Ni particles meshed between the Au-electrode and the Al film is significantly small because the particle diameter of the Ni particles is smaller than the thickness of the film after thermal bonding; and

it is impossible to cope with the variation in height (approximately 3  $\mu\text{m}$ ) of the Au-electrode, or the like.

Furthermore, the result shows the reason of lowering insulating properties in the plane direction of the film that a plurality of the Ni particles flow into the recess between the Au-electrodes by the flow of the resin causes short circuit between both of the electrodes. The results shown above confirm that only the first particles of Jin et al. having a small particle diameter cannot impart good anisotropic conductivity to the film.

Further, the anisotropic conductive film of Sample 2 including only Ni particles corresponding to the second particles in Jin et al. and having a diameter of 40  $\mu\text{m}$  is low in connecting resistance and good in conductivity in the thickness direction of the film. However, the result also shows that the anisotropic conductive film is low in insulating resistance and poor in insulating properties in the plane direction of the film. Then, the cross-section of the anisotropic conductive film after thermal bonding is enlarged and observed to show the reason of lowering conductivity in the plane direction of the film that the Ni particles having a large particle diameter are stuck in the recess between the adjacent

Au-electrodes to cause short circuit between both of the electrodes and lower the insulating properties.

Still further, the anisotropic conductive film of Sample 3 including only Ni particles corresponding to the second particles in Jin et al. and having a diameter of 40  $\mu\text{m}$  is high in connecting resistance and poor in conductivity in the thickness direction of the film. Moreover, the result also shows that the anisotropic conductive film is low in insulating resistance and poor in insulating properties in the plane direction of the film. Then, the cross-section of the anisotropic conductive film after thermal bonding is enlarged and observed to show the reason of lowering conductivity in the thickness direction of the film that, as described in our previous comment, the large amount of resin interposed between the Ni particles oriented in the thickness direction of the film is not smoothly discharged from between the Ni particles due to the pressure at the time of thermal bonding to remain therein, thereby hindering the electrical connection between the adjacent Ni particles. Moreover, as well as in Sample 2, the observation result shows the reason of lowering insulating properties of the plane direction of the film that the Ni particles having a large particle diameter are stuck in the recess between the adjacent Au-electrodes to cause short circuit between both of the electrodes.

The results shown above confirm that in the case where the combined with the second particles of having a large particle diameter to increase the conductivity in the thickness direction of the film, it is impossible to decrease the pitch between the electrodes to be smaller than the particle diameter of the second particles, thereby resulting in failure to satisfy



downsizing of the pitch between the electrodes.

In contrast to the above, when the cross-section the Example 4 is enlarged for observation to confirm that a plurality of the metal powders formed in a chain shape are meshed between the Au-electrode and the Al film to have conductive connection therebetween while coping with the variation in height (approximately 3  $\mu\text{m}$ ), thereby showing low connection resistance and good conductivity in the thickness direction of the film. Furthermore, the result also confirms high insulating resistance and good insulating properties since the metal powders formed in a chain shape are meshed between the Au-electrode and the Al film that the particles are restrained from flowing along with the flow of the resin at thermal bonding and bumping in, and still in combination with the fact that the chain length is smaller than the distance between the adjacent Au-electrodes, both of the electrodes are secure from short circuit therebetween.

<<Conclusion>>

The results of the experiments confirm that the anisotropic conductive film including a metal powder that has a lot of fine metal particles previously formed in a chain shape is less than the same as the one described in Jin et al. mentioned above, and has a good characteristic that Jin et al. does not provide.

I hereby declare that all statements made herein of my

own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 13th, June, 2007 By: Hideaki Toshioka  
Hideaki TOSHIOKA